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INSTRUMENTATION WITH CURRENT GENERATORS AND VOLTAGE TO FREQUENCY CONVERTERS

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Development and results regarding equipment for prospecting and accumulator testing

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INTRODUCTION

Prospecting

In geophysical investigations for water exploration and ore prospecting many indirect methods are utilized. The main objective is to study variations and anomalies, from which conclusions regarding the constituents and structure of the examined earth volume can be drawn. One physical variable that may vary considerably, is the electrical resistivity of the different layers of soil and rock below the earth surface. Hence it is possible to obtain information about those layers, if the resistivity distribution of the earth segment can be determined. A commonly used method is "the direct current method". A well-defined direct current is passed through an earth segment, by means of a current transmitter and two electrodes. With a voltage measuring device and two further electrodes placed over a minor part of the segment under investigation, the potential drop caused by the current stimulus is determined. This voltage is a weighted mean value for the conductivities of the different current paths below the measurement electrodes. If the current electrodes are further separated, the current will penetrate into deeper layers, and so the change in voltage will include information about the resistivities of those layers. In a typical series of measurements, the electrode separation is varied systematically. In this manner it is possible to map the resistivity distribution.

The voltage signal from the electrodes comprises the beneficial signal and different disturbances. The latter may be up to three orders of magnitude greater than the former. One method for suppressing the disturbances is to perform a series of integrating measurements. If some of the measurements are carried out with a current of inverted polarity, the beneficial signal can be calculated as the difference between these two kinds of measurements. A suitable way of performing the integrating voltage measurements, is to apply the signal to a voltage to frequency converter (VFC) and count the number of VFC-pulses per time interval. A Swedish company: ATLAS COPCO ABEM AB has developed and manufactured DC-resistivity measurement equipment for a long time. Three of the papers in this thesis report on the results of projects carried out at the Electronics Division in cooperation with ATLAS COPCO ABEM AB.

Accumulator testing

The Electronics Division has cooperated for a long time with a manufacturer of electrical accumulators: NIFE JUNGNER AB. This

cooperation has resulted in the development of several pieces of equipment for the testing of accumulators. Accumulators are used for many purposes, amongst others as an energy source for reserve power systems. When employed in this application, the accumulators are sometimes discharged with constant power, i.e. the discharge current is increased as the terminal voltage decreases. One of the papers describes a piece of test equipment that can simulate a constant-power load, by controlling a current generator so that the power is held constant. When performing this task, the equipment uses a signal that is proportional to the discharge-power, i.e. the product of current and voltage. This multiplication is performed with a multiplier built around a VFC.

The two groups of instrumentation mentioned above, have a common feature: they are both based on the development and usage of controlled current generators and voltage to frequency converters. Earlier work at the Electronics Division that has a connection with these techniques is that of Svenstam 1970, Alvsten 1974, Ljung 1976 and Karlsson 1978.

The thesis includes the following works:

A Laddningsdon för ackumulatorer, avsett för styrning av ström och effekt.
P Krill and E Ljung
Report AE3-75*

B JRM2 - ett jordresistansmätande instrument.
P Krill
Report AE1-79*

C Principer och egenskaper hos integrerande mätdon, avsedda för jordresistansmätningar.
P Krill
Report AE1-80*

D JRM3 - ett känsligt jordresistansmätande instrument med statistisk mätvärdesbehandling.
P Krill
Report AE1-81*

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SUMMARY OF THE PAPERS

A

The report describes an equipment for controlled charging and discharging of electrical accumulators. The equipment is a development of earlier work on the subject at the Electronics Division (Svenstam 1970 and Alvsten 1974). The equipment does not supply the current for the charging/discharging, and therefore an external voltage source is employed.

The new qualities are:

- The minimum voltage over the equipment terminals has been reduced from 6 to 2.5V.
- A capability of charging and discharging accumulators with constant power, i.e. when the terminal voltage decreases, the load current is increased. This task is performed with a maximum error of 1% when the load current is 20-200A, the accumulator voltage is 0.5-25V and the power is restricted to the range 25-5000W.
- Enhanced capability of holding the charge current constant, when fast variations are introduced by the external voltage source. Hence a three-phase rectified voltage may be used as an external voltage source, when the equipment charges/discharges accumulators with constant current.

B

An instrument is described that is intended for ground resistance measurements. It comprises two alternative current transmitters, one voltage measuring device and a control unit.

The current transmitters can transmit 0.2-20 and 0.2-500 mA respectively, with an accuracy of 1%. The compliance voltages are 175 and 500V respectively, with a restriction of the maximum power to 50W.

The measuring device has four ranges: 1, 10, 100 and 1000V. The smallest entity that may be resolved is about 40 microvolts. The analog to digital conversion is carried out with a voltage to frequency converter (VFC) that has the true ability of handling bipolar voltages. The number of pulses from the VFC during the measuring period is registered in a counter. In order to suppress random disturbances, it is possible to extend the measuring periods and to obtain the mean value from several measurements.

The measuring procedure of this instrument is in accordance with the method described in paper C. As the time base of the instrument is not very stable, the benefits of the above method are not fully utilized. However, as the VFC:s scale factor has a dependance on the time base that is equal in magnitude, but opposite in sign to, that of the measuring time´s dependance on the time base, the overall scale factor is independent of the drift of the time base.

C

Accomplishing a DC-resistance measurement includes the transmitting of a current through a ground segment, and extracting the voltage response over a minor part of the segment. The total voltage from the measuring electrodes may include a 500 mV DC-voltage, a 5 mV/S ramp-voltage, sinusoidal voltages with 250 mV amplitudes and frequencies of 16.7 resp 50 Hz (In Europe), and short pulses with a magnitude of 10 mV and a duration between 1 and 50 mS. The scale factor of voltage measuring instruments often have a time linear dependance, because of the temperature drift. This report describes a measuring procedure with certain disturbance-suppressing qualities. It also describes how an instrument working in accordance with this procedure, is affected by the factors mentioned above.

The procedure works as follows. During one measurement, three current pulses are passed through the ground. The first and the third pulses are of the same polarity and of the same duration. The second pulse is extended to twice this duration and has an inverted polarity. Synchronously with the pulses, the integrated responses of the pulses are determined. The value obtained as the sum of the responses from pulses one and three, subtracted from that of pulse two, is ideally the wanted net response. In reality, it is affected by disturbances. However, if the instrument is equipped with a three-pole low pass filter at the input and the capability of statistical treatment of a series of results, most disturbances are effectively suppressed.

D

The instrument described in this report is a development of the instrument JRM2 of paper B. The improvements are:

- The sensitivity has been increased. This has been made possible by the introduction of a sample and hold circuit that compensates for disturbing DC-voltages. Otherwise the input amplifier could easily become overloaded.

- The ability to suppress disturbances has been enhanced by the introduction of a crystal driven time base. Thus the benefits of the measuring method outlined in paper C are fully utilized.
- An ability to make statistical calculations on the discrete values of a mean value measurement series. This has been made possible by the introduction of microprocessors in the instrument.
- An autocalibrating function.
- A diagnostic measuring mode, which makes it possible to obtain quantitative information about the influence of disturbances.
- An interface which makes it possible to record the results of the measurements on a low-cost tape-recorder.

The software part of the instrument has been described with the help of a formal descriptive language which makes it possible to read and understand the aim, structure and function of the programme.

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